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The Distribution Dynamics of Output Multipliers in Scotland 1998–2007

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Abstract

In an input-output context the impact of any particular industrial sector is commonly measured in terms of the output multiplier for that industry. Although such measures are routinely calculated and often used to guide regional industrial policy the behaviour of such measures over time is an area that has attracted little academic study.

The output multipliers derived from any one table will have a distribution; for some industries the multiplier will be relatively high, for some it will be relatively low. The recent publication of consistent input-output tables for the Scottish economy makes it possible to examine trends in this distribution over the ten year period 1998 – 2007. This is done by comparing the means and other summary measures of the distributions, the histograms and the cumulative densities. The results indicate a tendency for the multipliers to increase over the period. A Markov chain modelling approach suggests that this drift is a slow but long term phenomenon which appears not to tend to an equilibrium state.

The prime reason for the increase in the output multipliers is traced to a decline in the relative importance of imported (both from the rest of the UK and the rest of the world) intermediate inputs used by Scottish industries. This suggests that models calibrated on the set of tables might have to be interpreted with caution.

Keywords: Input-Output analysis, Output Multipliers, Intermediate imports.

JEL Classification: C67, R11, R15

1. Introduction

The recent publication of consistent annual input-output tables relating to the Scottish economy for the ten year period 1998 to 2007¹ provides a data resource of a type that is uncommon in regional economics. As yet there appears to be little, if any, published work analysing the behaviour of the Scottish economy over the turn of the millennium as evidenced by these tables. This paper examines the behaviour over time of the Type 2 Output multipliers which may be derived from the tables. These tables contain 126 separately identified industrial sectors. However three of these sectors are of little interest here. First, there was no activity attributed to the Tobacco sector over the whole period, second, the only activity attributed to the Sugar industry over the period was a small amount in 1998 so it has been subsumed into the Other food products sector and third, the only activity attributed to the Metal ores extraction industry over the period were small amounts in 1998 and 1999 so that has been subsumed into the Other mining and quarrying sector. As a result the analysis that follows is based on a 123 sector industrial disaggregation of the Scottish economy. Attention is focussed on the distribution of the multipliers and how that changes over time.

In the second section of the paper a number of comparisons are made which show that there is a general tendency for the multipliers to increase over time. The question of what specific changes are taking place in the table to cause the drift in multipliers is addressed in Section 3. In the final section more general explanations are suggested that might lead to such changes and an implication for modelling is drawn.

2. The Dynamics of the Distribution of Type 2 Output Multipliers

In this section the ways in which the distribution of Type 2 Output multipliers derived from the annual Scottish input-output tables are examined. Figure 1 shows ten histograms (one for each year) using a common scale for the ten sets of multipliers. It is, perhaps, difficult to infer much from this representation but closer inspection reveals that the distributions do vary across the ten years and the most marked difference appears to occur between 2000 and 2001 when the histogram appears to shift noticeably to the right. Figure 2 shows various summary statistics for the distributions of the multipliers and it is clear that, over time the average value tend to increase (markedly between 2000 and 2001), the standard deviation also increase but at a greater rate so that the coefficient of variation also

¹ <http://www.scotland.gov.uk/Topics/Statistics/Browse/Economy/Input-Output/Downloads>

increases. Further insight may be obtained by noticing that whereas the maximum multiplier value increases over time as one might expect given the previously mentioned results but the minimum value decreases slightly hence the range increases over time.

As a final comparison the cumulative density functions of the ten sets of multipliers are given in Figure 3. Inspection of these indicates that, in the main, there is a steady shift to the right over the period 1999 to 2001, there is little systematic movement in the distribution function between 2001 and 2005 and there is a rightward drift over the period 2005 to 2007. Pairwise comparisons of the distribution may be made using the Kolmogorov-Smirnov test; the results are shown in Table I. The results suggest that in the three early years 1998 to 2000 the distributions of the Type 2 Output Multipliers were significantly different from those of the later years. However the pairwise tests are not independent of each other and therefore an overall view formed from the results might be misleading. A search of the literature suggested that there is no widely available and accepted k-sample generalisation of the Kolmogorov-Smirnov test which tests the hypothesis that all k distributions are the same against the alternative that they are not all the same. However the Jonckheere-Terpstra test (Jonckheere, 1954) tests the hypothesis that the distributions are the same against the alternative that the distributions are ordered (i.e. either shifting to the right or to the left). The p-value for this test is 0.047 indicating significance at $\alpha = 0.05$.

From these results it seems reasonable to conclude that the Output Multipliers tended to increase over the period for which the tables were constructed. This inference is reinforced by observing that, if one fits a simple linear trend to each individual industry's output multiplier, out of the 123 industries 111 exhibit positive trends (84 being significant at the 5% level) and only 12 negative trends (of which 4 were significant at the 5% level).

An additional perspective may be gained if the annual movements of the multipliers are modelled using a Markov chain model:

$$S_{t+1} = P \cdot S_t \quad ,$$

where S_t is the "state" at time t and P is a transition matrix. Two crucial decisions have to be made before one can implement the model. First, one needs to determine how many states there should be and second what ranges they should cover. There are no "right" answers to these questions and any results obtained may not be robust to these choices. In the work reported in this paper eight "states" were chosen [(<1.625) , $(1.625 - 1.7)$, $(1.7 -$

1.75), (1.75 – 1.8), (1.8 – 1.85), (1.85 – 1.9), (1.9 – 2.0), (>2.0)]. The transition matrix was estimated by considering all the non-overlapping annual changes [1998-1999; 2000-2001; 2002-2003; 2004-2005 and 2006-2007). Non-overlapping years were used to avoid interdependence between the readings. The ranges for the eight states were chosen to give a fairly even spread of occurrences in each starting state (80, 93, 89, 86, 80, 59, 77, 51). For any one value of a multiplier starting in state k the following value may be in k or in a different state. Thus the 615 (5x123) annual changes observed may be collated into an 8x8 matrix and hence converted into a matrix of probabilities where each element refers to the probability of a multiplier in state h in year l being in state k one year later.

The results of applying this model to the data as described suggest that the Markov process has an absorbing state (>2.0) which suggest that there may have been no limit to the growth of Type 2 output multipliers. However it should be noted that the speed at which the multipliers tend to the absorbing state is very slow. If one standardises the multipliers before carrying out the modelling exercise the results indicate that there is a slow convergence to a steady state distribution of standardised multipliers.

Although the complete set of analyses has not been completed for the Type 1 output multipliers nor for the Consumption effects (the value of the Type 2 multipliers minus the value of the Type 1 multipliers), their respective mean values indicate that that they both increase over time in much the same way as the Type 2 values.

3. An explanation for the increase in Type 2 multipliers.

The size of the multipliers is determined, in part, by the extent to which injections into the economy leak out. An initial injection, for example an increase in Exports of a sector, results in an immediate increase in the output of that sector and hence an increase in the inputs required in that sector to produce that increased output. The increased demand, from the sector, for the outputs of industries to use as intermediate inputs, results in increased demand for all sectors' outputs, which in turn generates further increase in output. The final outcome of this on outputs is given by the Type 1 output multipliers. If we endogenize households then the additional wages and salaries that are paid to households as a result of the initial expansion of the sector experiencing the export growth feed back into increased demand for the products of all sectors by increasing demand from the household sector as a

direct result of the increase in wages and salaries. This process is also cumulative, the final result of the combination of industrial and household effects being given by the set of Type 2 multipliers.

The size of the Type 2 multipliers is determined to a significant extent by the amount of the various stimuli that leak out of the system. If Type 2 multipliers are increasing then it follows that these leakages must be decreasing. For industrial sectors the leakages are imported intermediate inputs, gross operating surplus and taxes less subsidies. For households the leakages are imported goods purchased and household saving.

Figure 4 shows the behaviour of total industrial leakages (relative to Total Industrial Gross Output) over the period which has declined. Initially this seems due to a fall in the relative importance of Gross operating surplus but after 2000 the fall is explained by a fall in the relative importance of imported intermediate inputs. Figure 5 makes it clear that imported industrial inputs from the Rest of the UK and from the Rest of the World were both declining in relative importance.

Analysis of the leakages from the household sector is more complicated. Income going to Households from Wages and Salaries is not equal to Expenditure by Households on goods and services the difference being unearned income (pensions, dividends, benefits etc.) and household saving neither of which are measured in an input-output table.

Consider a change in Total wages and salaries of ΔWS . The resultant change in demand for an industrial output ΔX_j is given by

$$\Delta X_j = \frac{HDX_j}{TWS} \cdot \Delta WS = \frac{HDX_j}{THX} \cdot \frac{THX}{TWS} \cdot \Delta WS$$

where HDX_j is household expenditure on domestically produced j

TWS is Total wages and salaries

and THX is Total Household Expenditure

Figure 6 shows the ratio of Total Household Expenditure to Total Wages and Salaries which declines over the period, markedly so between 1998 and 2001. Other things being equal a fall in this ratio would be associated with a smaller impact on industrial production from any change in Wages and Salaries and thus be expected to lead to a fall in the values of the Type

2 multipliers and, naturally, the induced effects. However, as remarked at the end of the previous section, the evidence is that the induced effects actually increase over the period. It must be that the effect of the fall in importance of imported intermediate inputs, which will be to increase multipliers, outweighs any countervailing effect of the decline in the ratio of Total Household Expenditure to Total Wages and Salaries.

Figure 6 also shows the proportion of household expenditure which is made on imported goods and services and that broken down between RUK and ROW sources. The fall in the imported proportion between 2000 and 2001 seems to be mostly due to a fall in the proportion of household expenditure being spent on RUK imports; the rise from 2000 to 2007 is due to the rise in the proportion of household expenditure spent on goods and services sourced from both RUK and ROW. A fall in these import ratios would imply a fall in leakages from any stimulus and thus a rise in multipliers and a rise the reverse. However there would not appear to be any significant trend in the import ratios over the decade studied.

4. Inferences and implications

The fall in the relative importance of imported intermediate inputs could arise from a number of scenarios. In further work it is hoped to be able to study the relative importance of these scenarios in explaining the observed trend in the ratio. Such scenarios may be divided into those that can occur without any change in prices and those that involve relative price changes.

A growth in outsourcing, but not off-shoring, in Scotland would increase domestically produced intermediate inputs without increasing imported intermediate inputs. It is also the case that if those sectors that grew relatively quickly in Scotland were ones with relatively larger domestically sourced intermediate inputs then that too would lead to higher output multipliers.

Alternative explanations can be found if relative prices vary. Imported intermediate input prices could have fallen relative to domestically produced intermediate inputs. If there were no induced switching of input sources this too would lead to a rise in the output multipliers. However it is much more likely that there would be an induced quantity effect as Scottish

producers switch to the cheaper imported inputs. That would moderate any effect on the multipliers.

The investigation of such explanations for the phenomena of relative fall in imported intermediate inputs into Scotland would be of historical interest at the least, especially perhaps as the period coincides with the development of Scottish devolution. There may, nevertheless, be a concern in a different direction. Using any one of the set of input-output tables as a basis for modelling the behaviour of the Scottish economy would not appear to introduce any problematic structure into the modelling. However if one was devising a dynamic model for the economy and wished to calibrate it on the time series of tables then one should be aware that the increase in output multipliers over time would be built into the system and problems might arise because of the possible instability caused by that.

References

Jonckheere, A. R. (1954). "A distribution-free k -sample test again ordered alternatives". *Biometrika*, **41**: 133–145

Table I: Pairwise Kolmogorov-Smirnov statistics (p-values)

	M99	M00	M01	M02	M03	M04	M05	M06	M07
M98	.709	.144	.000	.000	.000	.000	.000	.000	.000
M99		.528	.000	.004	.000	.004	.000	.000	.000
M00			.012	.077	.003	.027	.002	.000	.000
M01				.811	.957	.403	.709	.191	.249
M02					.498	.498	.320	.106	.077
M03						.191	.811	.320	.077
M04							.144	.055	.003
M05								.811	.403
M06									.811

Shaded cell values indicate significantly different distributions ($\alpha = 0.05$)

Figure 1: Histograms of the distributions of the Type 2 Output Multipliers

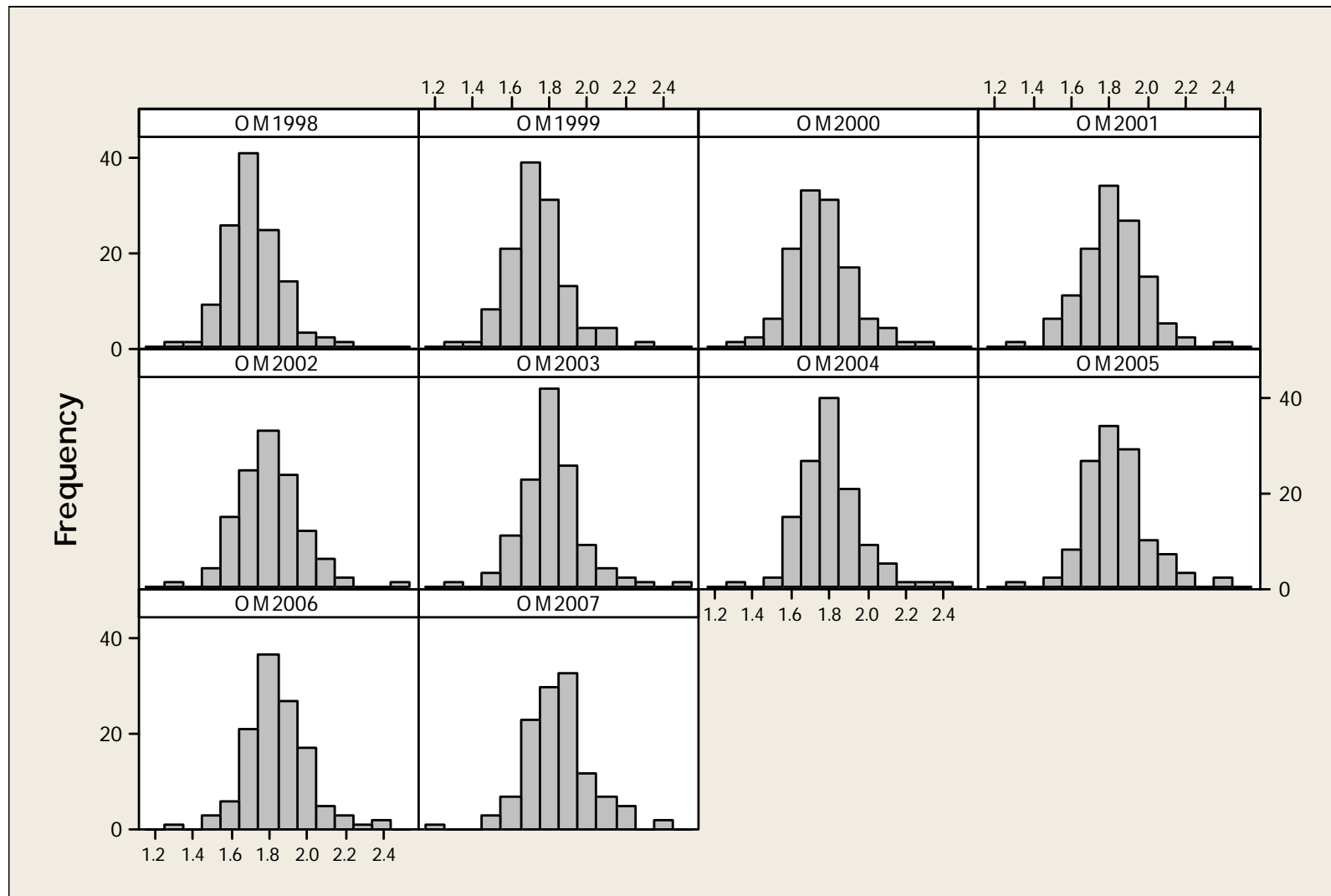


Figure 2: Summary statistics for the ten sets of Output Multipliers

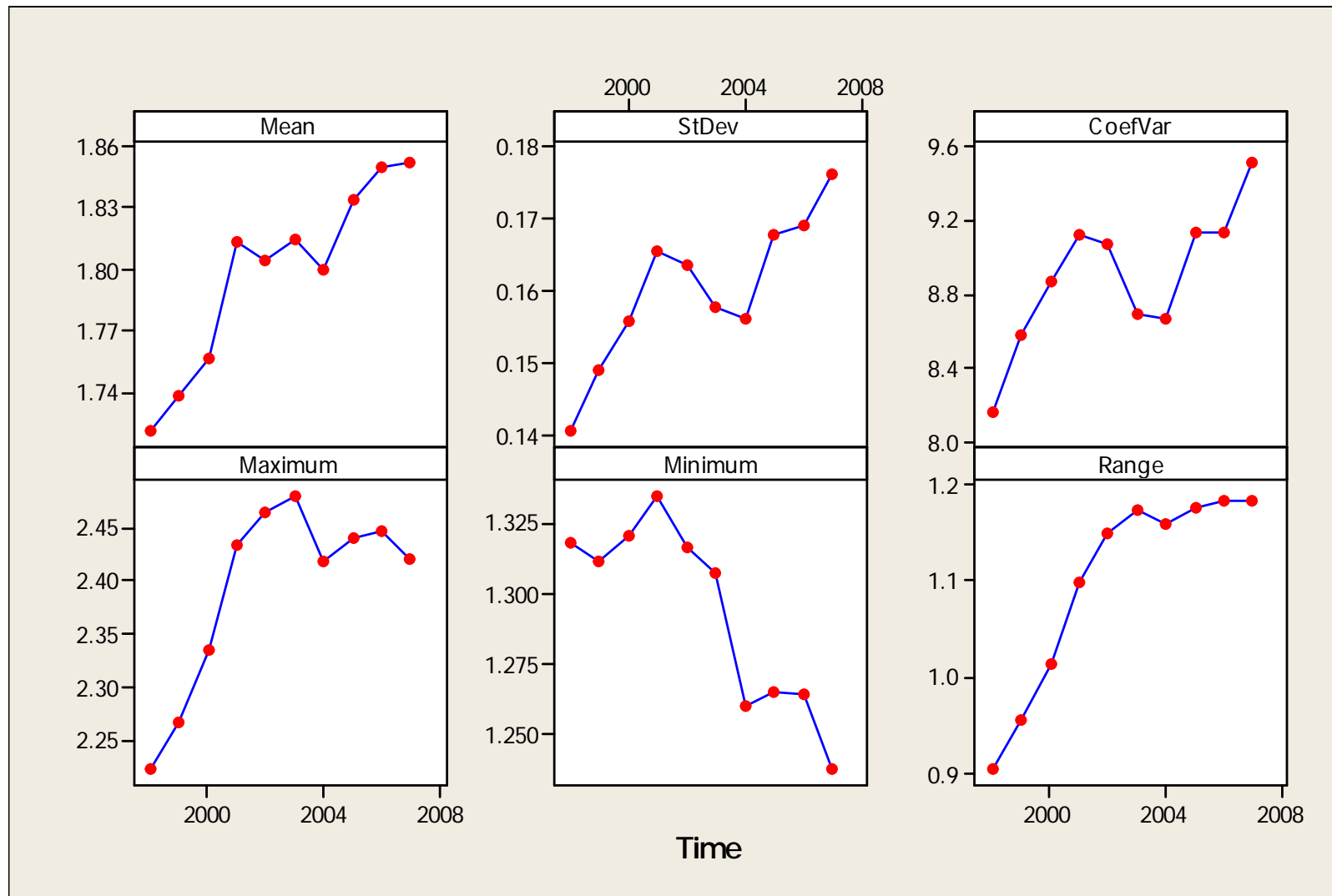


Figure 3: Cumulative Distribution Functions for the Output Multipliers

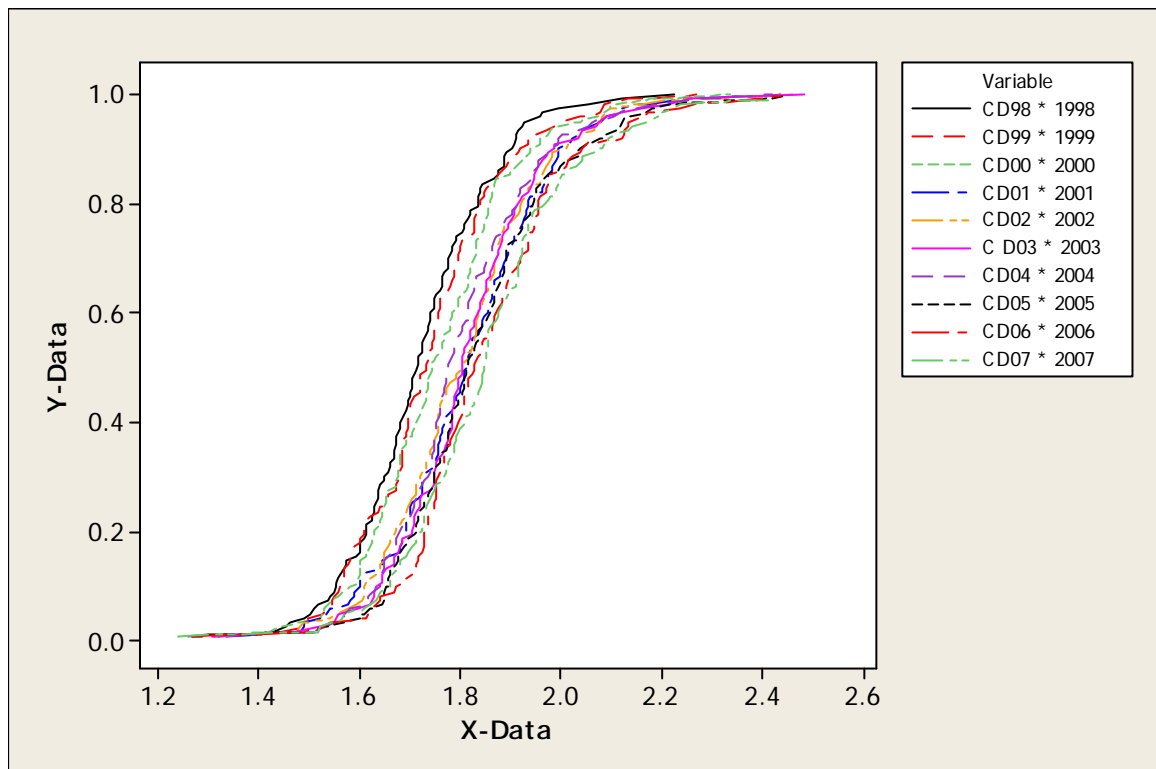


Figure 4: Total Industrial leakages, Gross operating surplus, Imported intermediate inputs and Taxes less subsidies (relative to Total Industrial Gross Output) 1998 – 2007

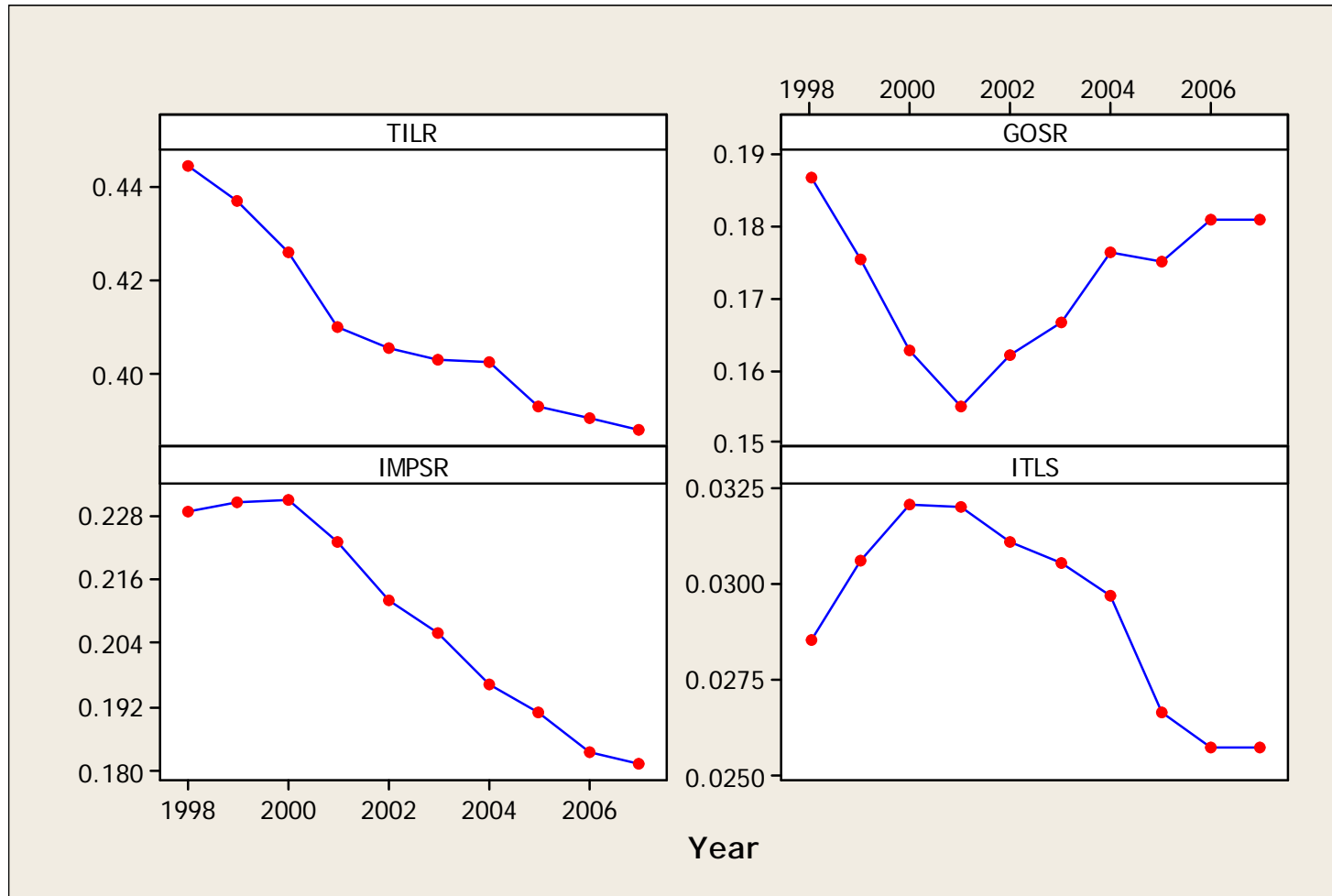


Figure 5: Total imported intermediate inputs, Intermediate inputs imported from the Rest of the UK and Intermediate inputs imported form the Rest of the World (relative to Total Industrial Gross Output) 1998 - 2007

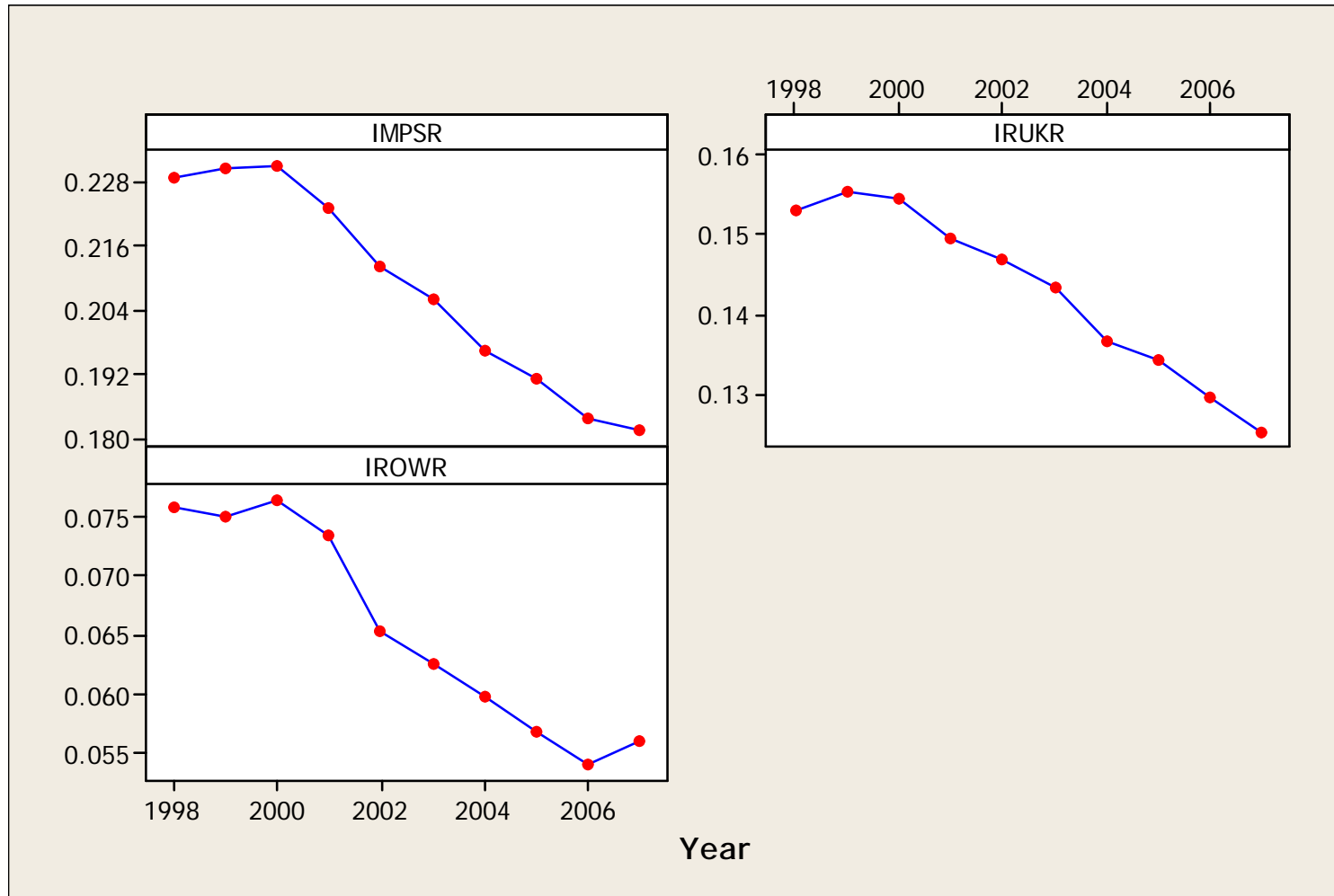


Figure 6: The Total Household Expenditure to Total Wages and Salaries ratio, the proportion of household expenditure spent on imported goods and the split between RUK and ROW sourced imports.

